Frontal Dynamics in the Middle Atlantic Bight: Analysis of Seasoar Data from the ONR Shelfbreak Primer Experiment

Glen Gawarkiewicz
Mail Stop 21
Woods Hole Oceanographic Instituition
Woods Hole, MA 02543
Phone: (508) 289-2913 fax: (508) 457-2181 email: ggawarkiewicz@whoi.edu

Robert C. Beardsley
Mail Stop 21
Woods Hole Oceanographic Instituition
Woods Hole, MA 02543
Phone: (508) 289-2536 fax: (508) 457-2181 email: rbeardsley@whoi.edu

Kenneth H. Brink
Mail Stop 21
Woods Hole Oceanographic Institution
Woods Hole, MA 02543
Phone:(508) 289-2535 Fax:(508) fax: 457-2181 email: kbrink@whoi.edu

Award Number#: N00014-98-1-0059

LONG-TERM GOAL

The goal of the Shelfbreak PRIMER frontal component is to investigate the dynamics of shelfbreak processes leading to frontal variability. In collaboration with the acoustics component of this experiment, we are also interested in learning how the oceanographic variability affects sound propagation from the continental slope to the continental shelf.

OBJECTIVES

The objectives of this project are to analyze the SeaSoar data collected during the Shelfbreak PRIMER Experiment to examine how seasonally varying stratification and forcing such as wind stress and heat flux affects the variability of the shelfbreak frontal structure.

APPROACH

We are presently investigating the spring data set, which consists of four long cross-shelf sections, several shorter cross-shelf sections, and a few along-isobath sections. This data set is excellent for starting the analysis because the front was not strongly forced by winds or warm core rings and also was relatively straight with no meandering. This allows us to look more closely at the unforced frontal configuration and secondary circulation.

WORK COMPLETED

The SeaSoar data from the spring cruise has been de-tided (barotropic) and all of the data have been objectively mapped. Potential vorticity maps for the four cross-shelf sections have been created. The individual terms within the potential vorticity distribution have been analyzed to determine the key components within different regions of the front. Standard diagnostic techniques of analysis are presently being applied to infer the ageostrophic secondary circulation within the front. Work has also continued on objective mapping and preliminary analysis of the summer and winter data sets, along with collaborative work with a number of other PRIMER components. A manuscript on the climatological structure of the front appeared (Linder and Gawarkiewicz, 1998).

RESULTS

The frontal configuration during the spring conditions contained numerous surprises. The cross-shelf temperature gradients were largest in the depth range of roughly 30 to 70 m, where the coldest shelf water abutted warm slope water (Figure 1). In the upper 20 m of the water column, there were very large salinity and density gradients (Figure 2). The potential vorticity structure was complicated near the outcrop of the surface front (Figure 3), where the potential vorticity maximum located at the depth of the seasonal pycnocline (20 m depth) was weakened by the vertical orientation of the outcropping isopycnals. Maximum surface velocities were as large as 60 cm/s, with relative vorticities which were quite large. The most surprising feature was a second alongshelf jet located near the foot of the front which appears to have resulted from the cross-shelf density gradients near the foot of the front.

IMPACT/APPLICATION

The frontal structure we have observed for the spring case is more complicated than previously imagined, with extremely large thermal gradients at mid-depth and strong surface density gradients. This has important implications for the secondary circulation of the front, the stability of the front, and the propagation of sound between the shelf and slope. The possible existence of a near-bottom jet is important to the structure of the detached bottom boundary layer which rises offshore along the frontal isopycnals. This coupled acoustic/physical oceanographic data set will be useful in understanding oceanographic contributions to acoustic variability in shallow water environments.

TRANSITIONS

Data collected during this experiment has been used by a wide variety of other research groups, including those working on acoustic propagation through the front, forecast modelling of the front, tidal analysis of the Middle Atlantic Bight, and stability analysis of the front.

RELATED PROJECTS

1. We are investigating the structure of the detached bottom boundary layer within the frontal zone with R. Pickart of WHOI.

2. The basic seasonal frontal structure has been used as a guideline for S. Lozier of Duke University for a stability analysis of the shelfbreak front. Some of the preliminary analysis of unstable modes shows some striking correspondence with observed features such as the jet structure near the foot of the front.

3. We are collaborating on several acoustic propagation studies looking at observed variability during the summer PRIMER observations.

PUBLICATIONS

Linder, C., and G. Gawarkiewicz, 1998: A climatology of the shelfbreak front in the Middle Atlantic Bight, Journal of Geophysical Research-Oceans, 103, 18,405-18,424.

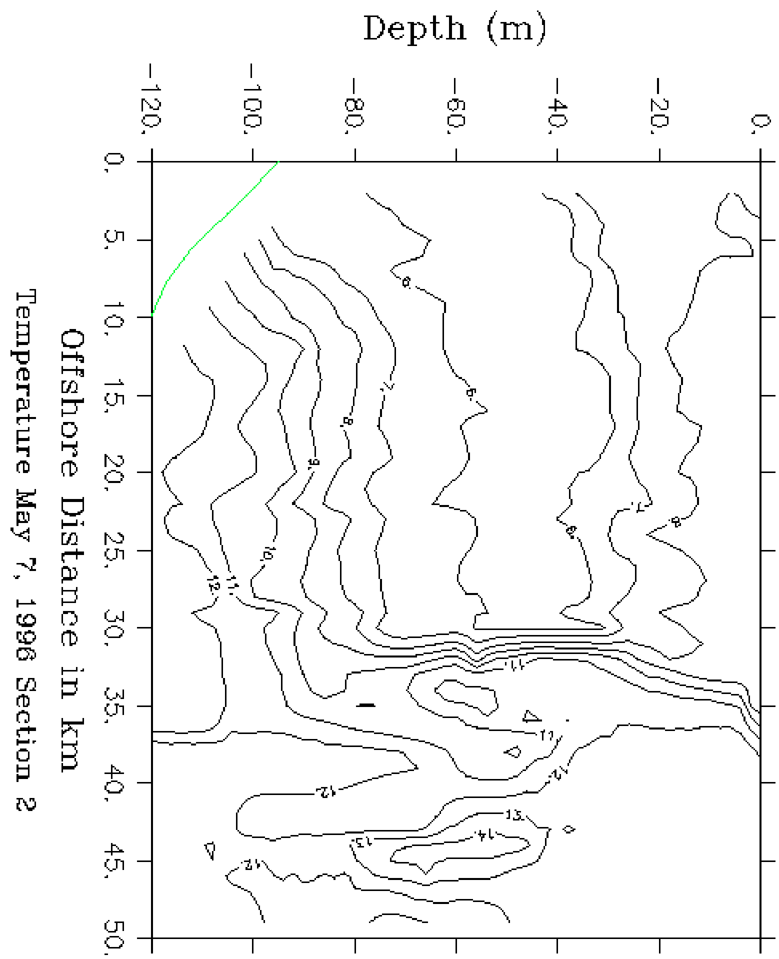

Figure 1- Temperature structure within the shelfbreak front from May, 1996. The largest thermal gradients are at a depth between 40 and 60 m, where the coldest shelf water abuts warm slope water.

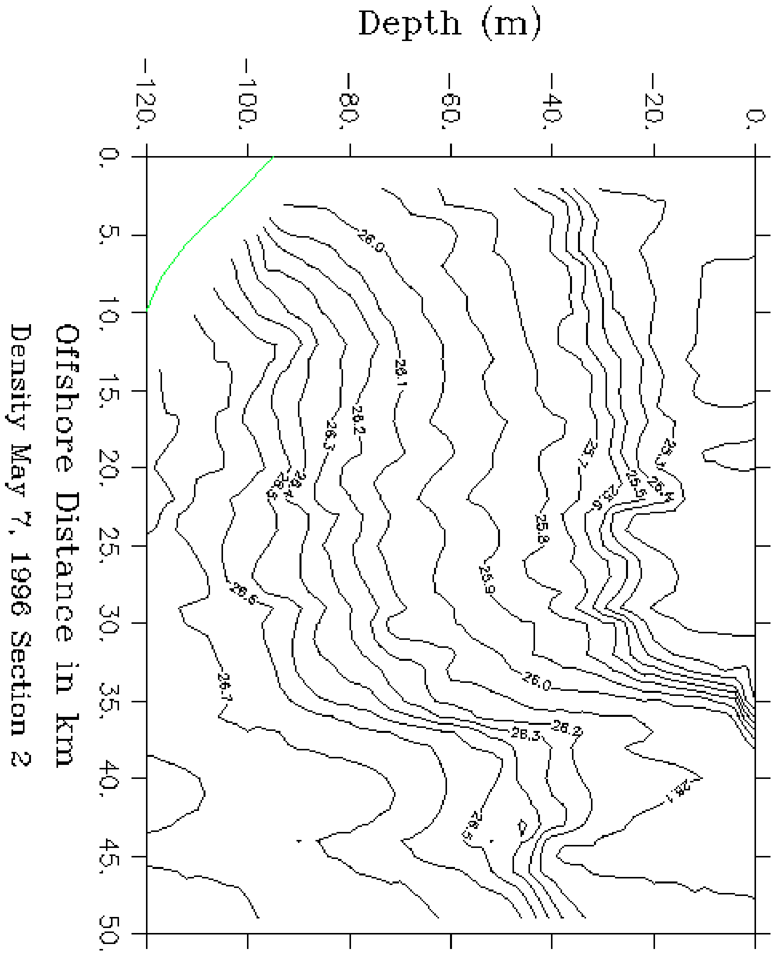

Figure 2- Density structure within the shelfbreak front from May, 1996. The strongest cross-shelf density gradients are within the upper 20 m of the water column, but there are also appreciable gradients down to a depth of 100 m beneath the surface outcrop as well as near the foot of the front.

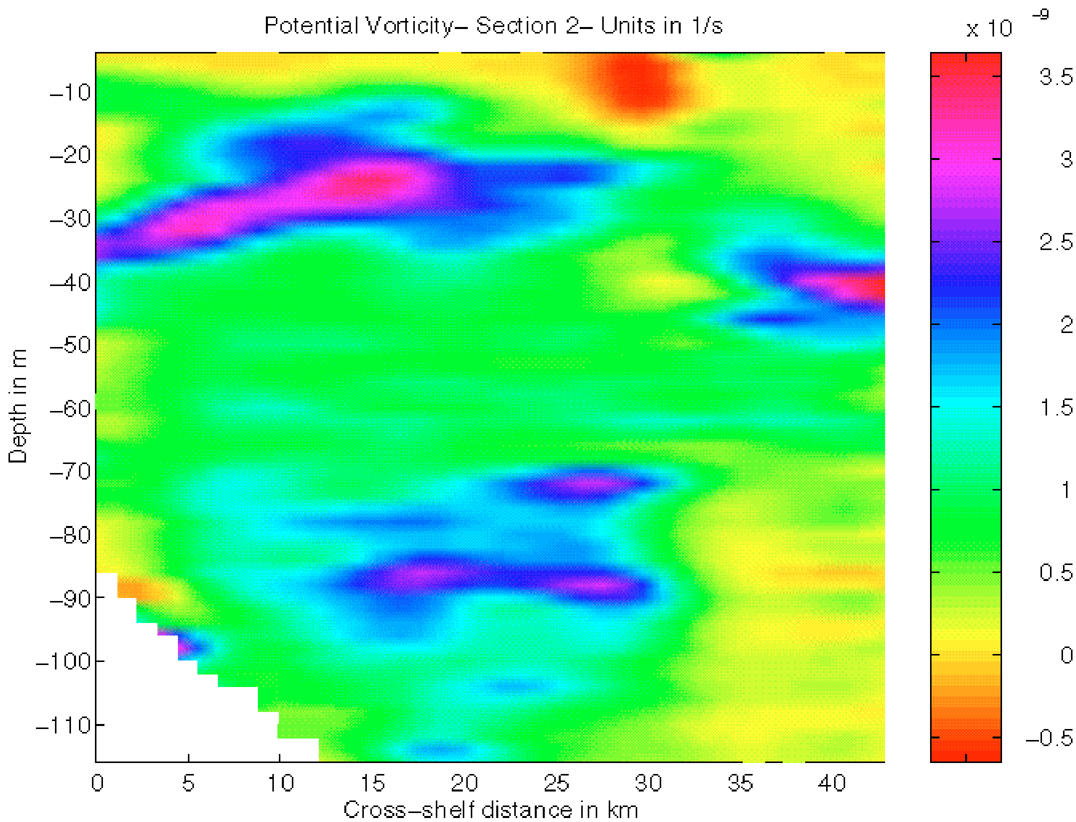

Figure 3- Potential vorticity structure within the shelfbreak front from May, 1996. The largest values occur between depths of 20 to 30 m within the seasonal pycnocline and between 70 to 90 m near the foot of the front. Values are low near the surface, with a local minimum near the surface outcrop of the front.